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**HOW FULGUR AND SYCOTYPUS EAT OYSTERS, MUSSELS AND CLAMS.**

BY HAROLD SELLERS COLTON.

Since observations on the habits of Prosobranch mollusks are fragmentary and few, I embraced an opportunity of studying *Fulgur carica*, *Fulgur perversa* and *Sycotypus canaliculatus* under conditions as nearly natural as one can hope to have in a laboratory located far from the sea. Most of the observations were carried out in the Vivarium of the University of Pennsylvania; these were supplemented by studies on fresh material under more natural conditions at the Fisheries Laboratory at Woods Hole.<sup>1</sup>

The individuals studied in Philadelphia had been in captivity a long time. All had been there a year and many several years. The *Fulgur carica* had come from Woods Hole and the Jersey coast. *F. perversa* I had brought up from Clearwater, Florida, two years and a half before. Of these latter none had died a natural death during that time.

The salt water aquarium in which they were confined was about five feet wide and eleven feet long. There was three feet of water over the greater part, but a shallow beach at one end.

On the beach I was accustomed to place oysters that I kept as a stock to feed the animals in this tank. Every week I chopped up an oyster or two and distributed the juice and fragments all over the tank. This stimulated the Fulgurs and Sycotypi to activity and to make frequent raids on the living oysters on the beach. This led me to inquire into the kind of food, the amount of food, and method of feeding of these gasteropods.

There is but one actual observation on the manner of feeding of these mollusks that I have been able to discover. Stimpson (1860), in speaking of *Sycotypus*, said: "In eating (it) applies end of proboscis to the clam's foot, and with a sudden jerk of the lingual ribbon inward and sidelong takes a strip of flesh."

The "impression" that most persons hold with reference to the manner of eating and the habits of the *Sycotypus* and *Fulgur* is expressed by Herrick (1906): "Since this animal is a great pest to the oystermen and clam-diggers, . . . it is of some interest . . . to know . . .

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<sup>1</sup> I am deeply indebted to the United States Commissioner of Fisheries for the use of a table at the Woods Hole Laboratory, to Dr. F. B. Sumner, the Director, for many favors, and particularly Dr. E. G. Conklin for reading the manuscript of this paper and for many helpful suggestions.

how this gasteropod accomplishes its destructive work of boring through the shells of oysters and clams and rasping out their soft contents by means of the file-like tongue." Although this is in the introduction, he does not mention again how *Sycotypus* bores through shells and had only the "impression" that they did bore.

Ingersoll (1884) has given the most detailed description of the food and the manner of taking it that I have been able to discover. "The food of the conch (*Fulgur* or *Sycotypus*)," says he, "being mainly the flesh of other mollusks, its method of killing them is one of brute strength, since it is unprovided with the silicious, file-like tongue by means of which the small drills set at naught the shelly armor of their victims. The conch is a greater savage than that. Seizing upon the unfortunate oyster, unable to run away, he envelops its shell in the concave under surface of his foot, and by just such muscular action as you would employ in grasping an object in the palm of your fist, crushes the shell into fragments and feasts at leisure on the flesh thus exposed. One planter thought one Winkle (*Fulgur* and *Sycotypus*) was capable of killing a bushel of oysters in a single hour. They do not confine themselves to oysters altogether, of course; any mollusk or other animal sluggish or weak enough to be broken up suffers from their predacity. I was told in New Jersey by an intelligent man that a conch would even pull a razor clam out of its burrow and devour it. If this be true the soft shell clam also falls a victim to the same marauder. The Quahog is generally safe."

I quote this because my observations and experiments unfortunately contradict so many of these interesting statements.

My experiments as to the kind of food were restricted to live Lamelli-branches, because I never was able to observe them eat chopped oyster or chopped meat. Chopped oyster certainly stimulates them and perhaps they will eat it. I cannot tell. Table I gives the results of my studies at Woods Hole and Philadelphia. (x) indicates that the particular bivalve was fed to the conch and eaten; (o) indicates that it was fed to the conch and not eaten; and (-) means that the particular form was not supplied with the indicated food.

TABLE I.

	<i>Sycotypus</i> .	<i>F. carica</i> .	<i>F. perversa</i> .
<i>Mya</i> .....	x	x	-
<i>Venus</i> .....	0	x	x
<i>Ensis</i> .....	-	x	-
<i>Modiola</i> .....	0	x	-
<i>Mytilus</i> .....	x	x	-
<i>Ostrea</i> .....	x	x	x

At Woods Hole *Sycotypus* and *F. carica* were found only at places where *Ensis* (razor clams) were abundant. I could not find them on any other beach. Although I did not observe *Sycotypus* eating *Ensis*, I think there is every reason to suppose that they do.

The experiments on the amount of food are too few to be definite. The results, such as they are, are expressed in Table II. (x) indicates present but not eaten. (o) indicates not present.

TABLE II.

No.	Conch.	Days.	<i>Ostrea.</i>	<i>Mya.</i>	<i>Venus.</i>	<i>Mytilus.</i>	<i>Modiola.</i>
4	<i>Sycotypus</i> .....	10	x	13	x	7	x
4	<i>F. carica</i> .....	10	x	x	2	3	1
3	<i>F. perversa</i> .....	42	7	0	0	0	0
4	<i>F. carica</i> .....	42	0	0	0	0	0
2	<i>Sycotypus</i> .....	42	4	0	0	0	0
1	<i>Sycotypus</i> .....	2	4	0	0	0	0

Very often one individual would eat a couple of clams or oysters in a day, but as a rule the meals were far apart.

Notwithstanding most persons' "impressions," it is highly improbable that these mollusks ever bore through Lamellibranch shells. I have never seen a hole that would fit their proboscis, nor does the wearing of the teeth on the odontophore indicate that they were worn down against a hard substance. Plate I, figs. 3-4 show the median tooth of *Urosalpinx* which bores rapidly through the shells of mussels. The former shows a tooth before being worn and the latter a tooth worn down. These teeth compared with a similar series, Plate I, figs. 1 and 2, showing *F. carica*, suggest that there are two methods of wear. In *Urosalpinx* the teeth are worn evenly off so that a straight line will join the tops. The large teeth are worn level with the short ones. In *Fulgur*, however, the teeth are broken off in almost any way. Examinations of the radulæ of *Nassa obsoleta*, *Nassa trivittata*, *Lunatia* and *Purpura lapillus* seem to substantiate the view. But with the exception of *Purpura* and perhaps *Nassa obsoleta*, too little is known how they take their food to render any general conclusions tenable. In the case of these last two, *Purpura*, which has a radula worn like *Urosalpinx*, has been observed to bore (Wilcox, 1905); and *Nassa*, with wear such as I have described for *Fulgur*, has never been seen to bore, but will crawl between the valves of *Mya*, wedging the valves apart, and devour the flesh (Dimon, 1905).

The other method of attack (Ingersoll, 1884) is by breaking the shell. As described by Ingersoll this is utterly impossible. However,

both *F. perversa* and *F. carica* do injure the shell of *Venus mercenaria* (Quahog); and, although they leave marks on the shell of *Mytilus* (mussel) and perhaps *Ostrea*, the shell of *Mya* (soft shell clam) is left without a scratch.

In the case of *Sycotypus* eating oysters, I have been able to watch the whole process from the beginning to the end without interruption, so I will take this as my first example. It will be an account of the behavior of a single individual.

The *Sycotypus* had not been fed for a month or so and was buried in the gravel. To stimulate, I added some very finely chopped-up oyster to the aquarium. When it started to crawl out of the gravel, a few minutes after I added the oyster juice, I placed some live oysters in the aquarium with it. It attacked one of the oysters five minutes after I placed them with it. Fifty minutes afterward it left the empty shell. Going a foot to another oyster, it began to attack it twenty minutes after it left the first one.

The *Sycotypus* crawled on top of the oyster, which closed its valves. The conch waited two minutes when the oyster opened its valves (Plate II, fig. 7). Rotating its shell on the axis of the columella through an angle of  $70^{\circ}$ , it thrust its own shell between the valves of the oyster and introduced its proboscis between the shells (Plate II, fig. 8). Forty minutes later it left the empty shell.

*Sycotypus* does not wedge the shells of *Mya* apart, because it can get at the soft parts without doing so, since the valves gap slightly (Plates II and III, figs. 11, 12). To test this I introduced an oyster that had had three-quarters of an inch broken from the margins of both valves on the end away from the hinge so that the valves appeared to gap. I found that *Sycotypus* attacked this one in the same manner as it attacked *Mya* and did not wedge the shells apart (Plate I, fig. 6).

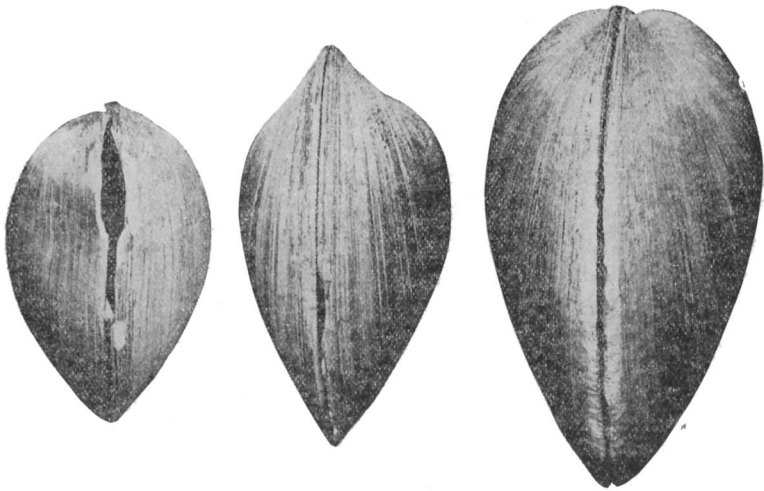
*Fulgur* eating *Venus* is a much more complicated case. The conch (*Fulgur perversa* or *F. carica*) grasps the *Venus* in the hollow of its foot (Plate IV, fig. 13), bringing the margin of the *Venus* shell against its own shell margin. By contracting the columellar muscle it forces the margins of the shells together, which results in a small fragment being chipped from the shell of *Venus*. This is repeated many times and, finally, the crack between the valves is enlarged to a width of 3 mm. or more (text fig.).

The proboscis is normally about 5 mm. to 8 mm. in diameter. There are three ways in which it may get at the animal. First, it may flatten out its proboscis so that it will go through the crack; secondly, it may pour in a secretion between the valves which kills the clam

and, thirdly, it may wedge its shell between the valves of the *Venus*. By contracting its columellar muscle it may actually wedge the valves apart. *Venus* is much more sensitive to mechanical stimuli than is *Ostrea*. *Venus* never opens its valves of itself when it is in the grasp of a *Fulgur*, while *Ostrea*, after the first shock, opens wide its valves as if no danger were near.

*Fulgur* and *Sycotypus* often break their own shell when opening oysters and clams, and this accounts no doubt for the irregular growth lines seen on their shells.

This method of inserting the margin of a gasteropod between the valves of a Lamellibranch has been noticed before. Francois (1890)



Quahog shell clipped by *Fulgur*.

briefly reports that *Murex fortispinna* has a special tooth on the margin of its aperture for the purpose of inserting between the valves of *Arca*. It may be that this manner of attacking the soft parts of bivalves is a very common habit of Prosobranch mollusks.

All writers recognize *Fulgur* and *Sycotypus* as pests to the oyster men. How many oysters will be destroyed will depend on the average number eaten in a given time. Although I have found them to eat two oysters one day and two the next, there follows a long rest period where the individual remains buried in the sand—sometimes for days, sometimes for months.

Notwithstanding that Ingersoll (1884) says, "It is needless to say that they do not burrow at all," I find that they are buried about 65

per cent. of the time, the tip end of the black siphon alone projecting above the sand—5 mm.—a most inconspicuous object.

The following table gives the records of the activity of nine individuals for a period of six weeks. It indicates the periods of rest and activity expressed in days. Plate V shows these periods of rest and activity distributed in space.

TABLE III.

Gasteropod.	Days active.	Days buried.	Days quiet.	Days of food.
<i>Sycotypus</i> No. 2.....	21	16	3	2
“ No. 10.....	2	38	0	1
<i>F. carica</i> No. 3.....	9	25	6	0
“ No. 4.....	5	34	1	0
“ No. 5.....	11	0	14	0
“ No. 6.....	10	4	26	0
<i>F. perversa</i> No. 1.....	7	29	4	1
“ No. 7.....	10	30	0	2
“ No. 8.....	7	33	0	1

These experiments were carried on in Philadelphia and so were not under perfectly natural conditions. They show how far apart the meal times are. During these experiments *F. carica* never ate. If these observations reflect at all the normal habits of the individual, they cannot, I think, be a very serious oyster pest.

*Sycotypus* and *Fulgur* do not always react to their food in the same manner, but they react to different Lamellibranchs in a way best suited to getting at the soft parts of the animals. Therefore the behavior is adaptive (Jennings, 1906, 1907).

Another question is, are these organisms intelligent? Jennings (1906) defines intelligence as a modification of behavior in accordance with experience. The usual way to test this is by habit formation (Jennings, 1907). “(1) The organism must be presented with a problem to be solved. (2) The organism must ‘try’ to solve the problem in several different ways. (3) It must be able to solve the problem in but one or a few ways.”

In accordance with these criteria I presented the mollusks with a simple maze problem with oysters as “bait.” Although without food for a week, they buried themselves in the sand and did not move again. At the end of two weeks I discontinued the experiment. To show the normal behavior of these animals I plotted their movements for a period of six weeks. This gave no results except those embodied in the earlier part of this paper. The diagrams show, however, how very sluggish these mollusks are. It is probably impossible by any of

the ordinary methods to determine the intelligence of *Sycotypus* and *Fulgur*. The solution of this problem awaits some ingenious future investigator.

#### SUMMARY.

1. *Fulgur* and *Sycotypus* are very hardy and live well in captivity.
2. *Fulgur* probably attacks any Lamellibranch.
3. *Sycotypus* will attack any except *Venus*.
4. Oysters are eaten in less than an hour. Clams in from an hour to an hour and a half. Quahogs from seven hours to three days.
5. They do not bore shells with the radula.
6. They open shells of oysters by wedging their own shell between the valves, and tear out the flesh with their radula. They probably treat Quahogs in the same way.
7. Some shells are injured in the process, depending on the amount of gap and the sensitiveness of the organism to mechanical stimuli.
8. Their meals are far between.
9. They spend their time between meals buried in the sand.
10. They may not be as serious a pest to the oystermen as previously reported.
11. Their behavior is adaptive. As yet we have no proof that these animals are intelligent.

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#### DESCRIPTION OF PLATES I-V.

Figs. 1 and 2 were drawn with the aid of a camera lucida and magnified about 72 diameters.

Figs. 3 and 4 were drawn with a camera lucida and magnified about 270 times.

The succeeding figures were drawn free-hand from living animals with the exception of figs. 7 and 8, which are semi-diagrammatic. They are  $\frac{3}{4}$  natural size.

PLATE I.—Fig. 1.—Median tooth of *Fulgur carica* (unused).

Fig. 2.—Median tooth of *Fulgur carica* (worn).

Fig. 3.—Median tooth of *Urosalpinx* (unworn).

Fig. 4.—Median tooth of *Urosalpinx* (worn).

Fig. 5. *Sycotypus* eating an oyster viewed from above.

Fig. 6.—*Sycotypus* eating an oyster viewed from side. The oyster had had the end toward the conch broken for about  $\frac{3}{4}$  inch.

PLATE II.—Fig. 7.—*Sycotypus* on top of oyster (semi-diagrammatic).

Fig. 8.—The same a few seconds afterward, showing the margin of the *Sycotypus* shell wedging apart the shells of the oyster.

Fig. 9.—*Sycotypus* wedging apart the valves of an oyster.

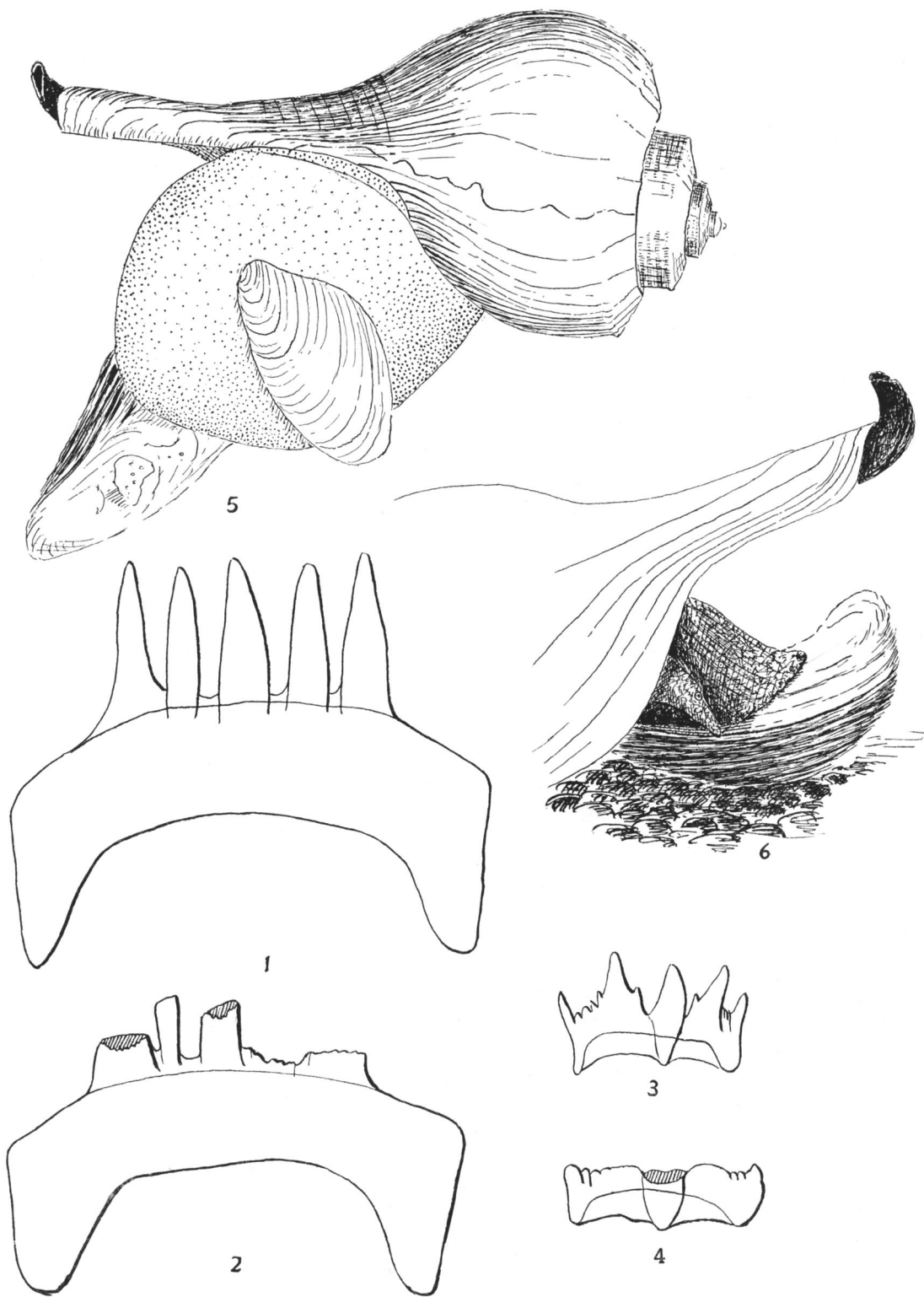
PLATE III.—Fig. 10.—*Sycotypus* in search of food.

Fig. 11.—*Sycotypus* eating *Mya*.

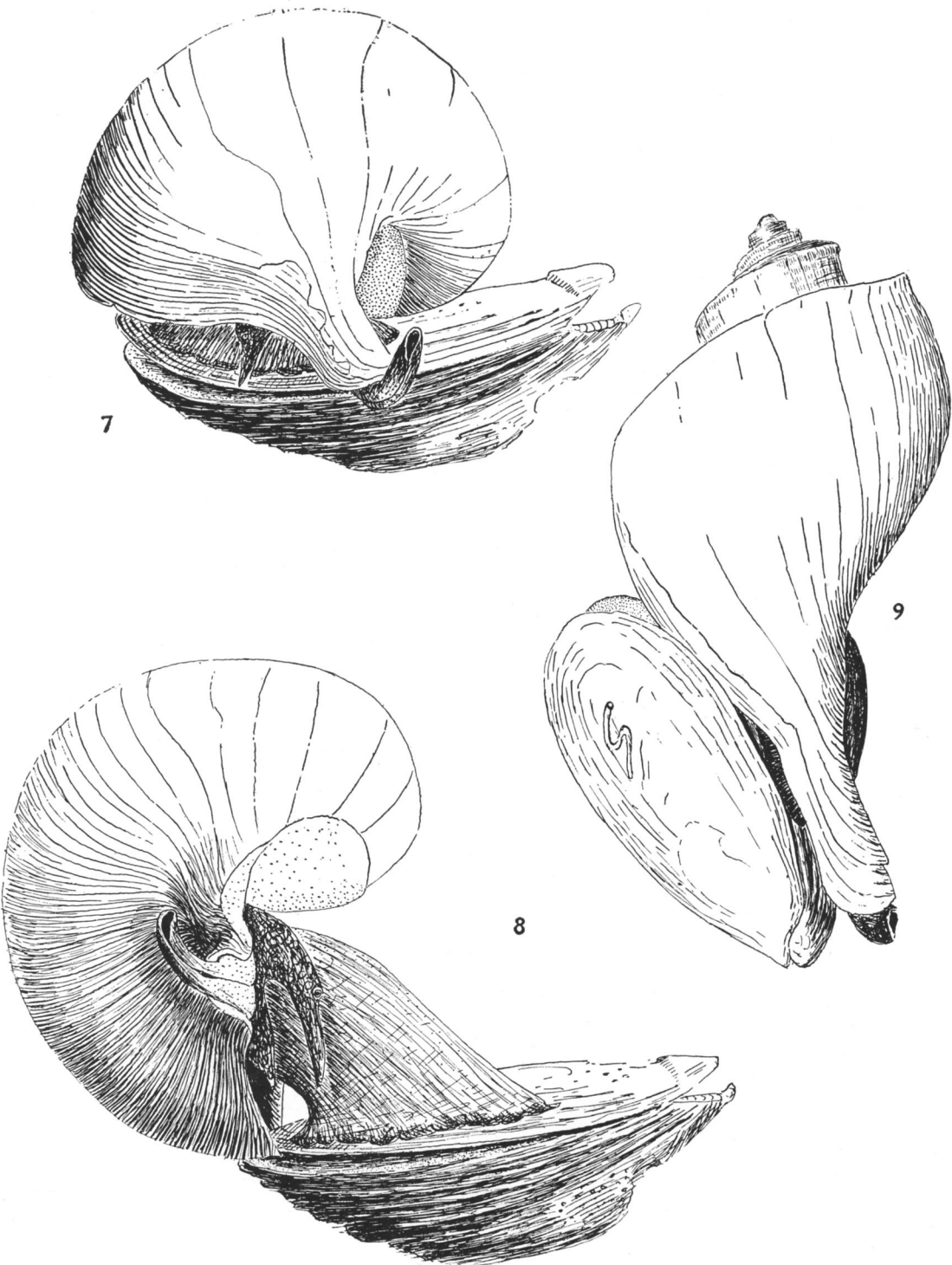
PLATE IV.—Fig. 12.—*Sycotypus* eating *Mya*.

Fig. 13.—*F. carica* eating *Venus*, showing how it holds the shell.

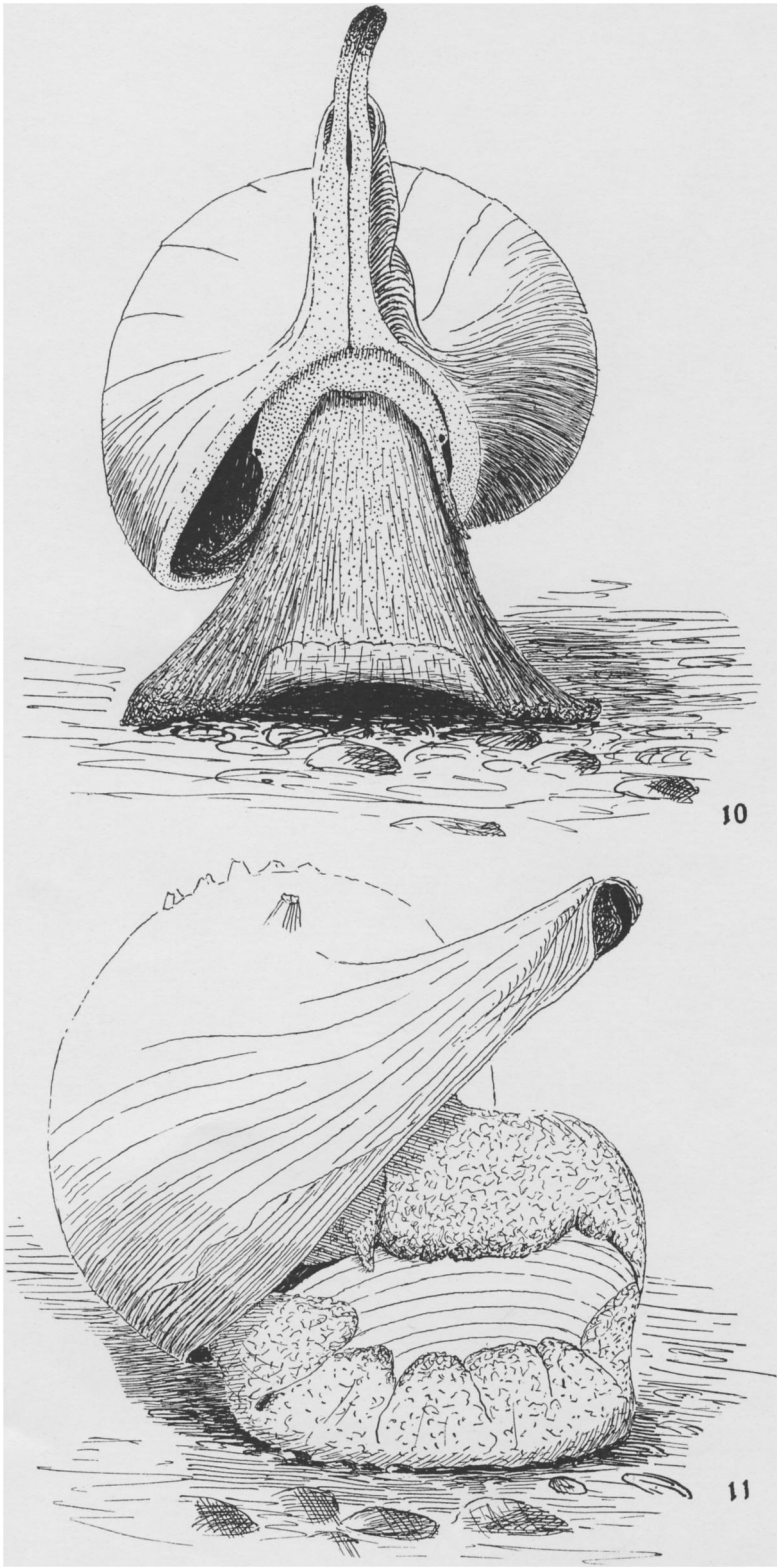
PLATE V.—Diagrams illustrating the wanderings of *F. perversa*, *F. carica* and *S. canaliculatus* during a period of six weeks. Each square of the diagram represents one square foot. Each of the diagrams represent an aquarium of salt water five feet by eleven feet. The plottings were made daily. The Roman numerals indicate the identification number of the individual welks. Arabic numerals indicate days at one spot. (o) means an oyster eaten. (B) indicates that the individual was buried.



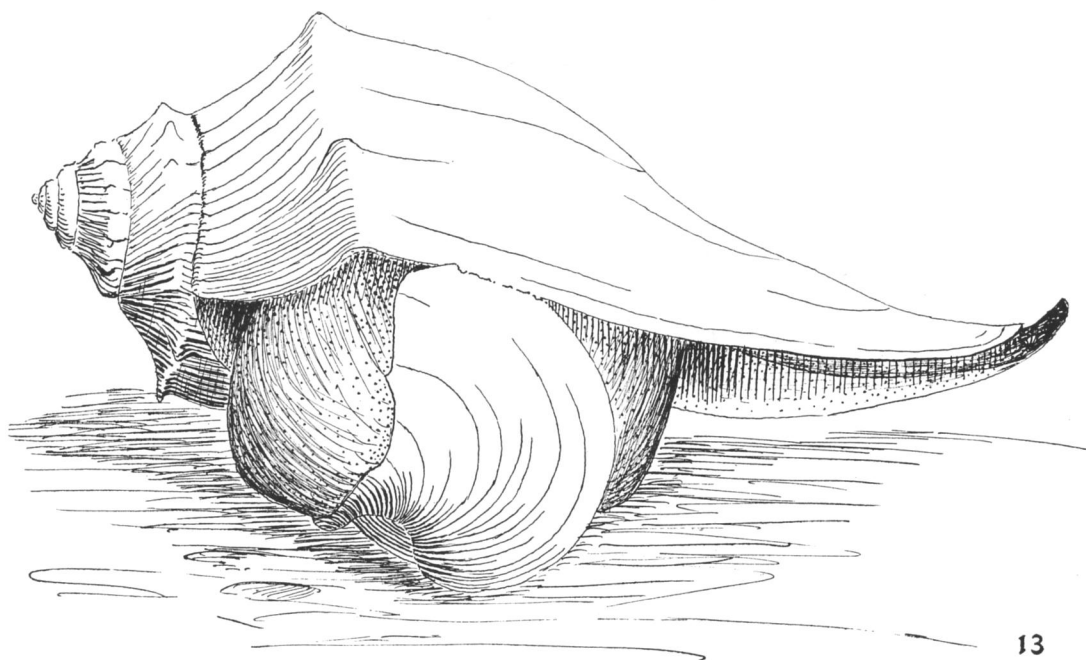
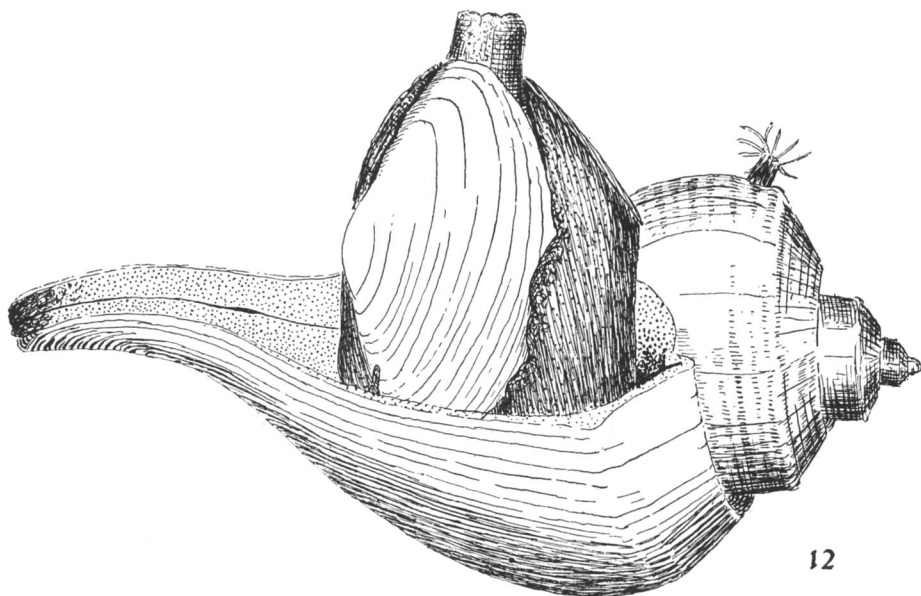
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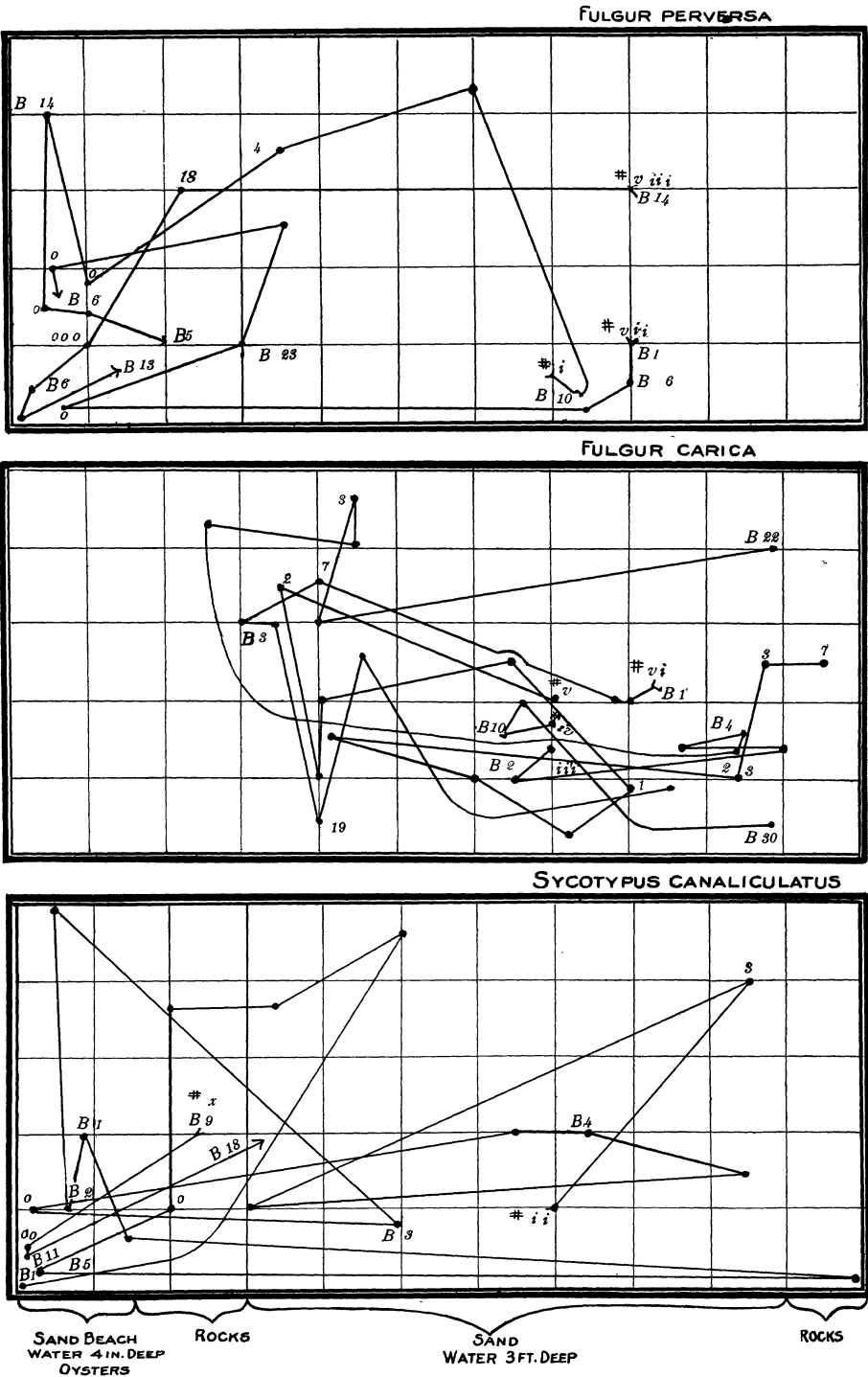


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